Corrosion Properties of Nanocrystalline Cobalt in 0.5 M Na_2SO_4 Solutions

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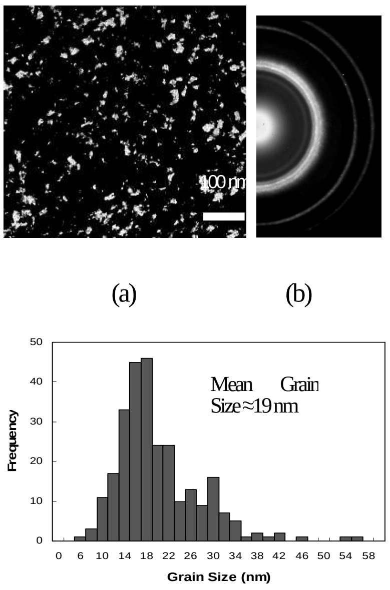
Cobalt and its alloys are of considerable interest from the point of views of some practical applications such as cobalt based superalloys, magnetic recording media, antiwear materials and surgical applications [1]. More recently, nanocrystalline cobalt and cobalt based alloys have been identified as the candidate materials for replacing hexavalent chromium plating in wear-resistant coating applications[2]. However, corrosion studies on cobalt in general have been rather limited and to date there have been very limited on the corrosion properties of nanocrystalline cobalt[3]. In order for successful exploitation of the alloy design principles to synthesize better materials than available, the understanding of the corrosion behavior is of large importance.

In this study, the corrosion properties of conventional polycrystalline cobalt with average grain size of 100 μm and nanocrystalline cobalt with average grain size of 19 nm (See Fig.1) produced by electrodeposition have been studied at room temperature using a potentiostatic and potentiodynamic polarization techniques in N_2 saturated 0.5 M Na_2SO_4 solution of pH 5, 7, 10 and 13. The chemical and physical characteristics of the uncorroded and the corroded surface of cobalt were examined by SEM, EDS, XRD and TEM.

In both cobalt samples, experimental results (See Fig.2) showed that increasing the pH shifted the entire polarization curve to more cathodic potential and decreased the corrosion current density. At pH of 5 and 7, the cobalt exhibited active dissolution and did not passivate. The anodic polarization curves of nanocrystalline cobalt were almost identical to those of polycrystalline counterpart including the E_{corr} value. At pH of 10, a slightly enhanced anodic dissolution current was observed for nanocrystalline cobalt. In strong alkaline solution of pH 13, the anodic polarization curves of polycrystalline and nanocrystalline cobalt exhibited a clear passivation region. The curve of nanocrystalline cobalt shifted significantly to cathodic potential and higher current density than polycrystalline cobalt, however, the differences in current density became negligible at high potentials. SEM micrographs of nanocrystalline cobalt after potentiodynamic polarization scans showed excessive uniform corrosion, while the polycrystalline cobalt showed less uniform corrosion..

References

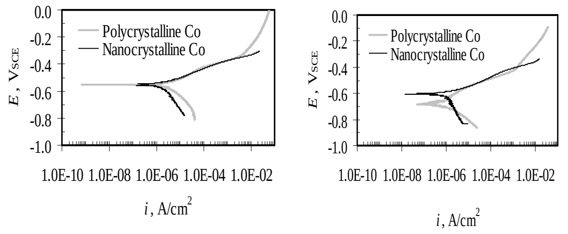
1. Paul Crook, Advanced Materials and Processes, Vol.4, p27-30 (1994)
2. U. Erb, Nanostructured Materials, Vol.6, p533-538 (1995)
3. H. Jung and A.M.Alfantazi, Metallurgical and Materials Transactions (submitted 2002)



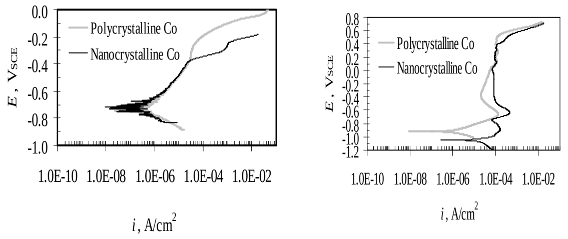
(a) (b)

(c)

Fig.1 Dark field (a) and TEM micrographs with electron diffraction pattern (b) and grain size distribution (c) of the as-deposited microstructure



(a) pH 5 (b) pH 7



(c) pH 10 (d) pH 13

Fig.2 Potentiodynamic polarization curves of poly- and nanocrystalline Co at (a) pH 5, (b) pH 7, (c) pH 10 and (d) pH 13 in 0.5 M Na_2SO_4 solutions at room temperature